Winter 2005

WIMS WORLD

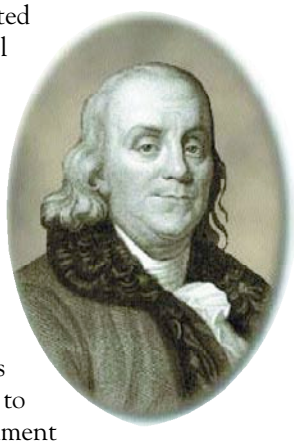
University of Michigan | Michigan State University | Michigan Technological University

Director's Message

The subject of *role models* has been on my mind again lately, so I'll share a few thoughts with you. When I was nearing the completion of my undergraduate career, I spent two days interviewing at Bell Labs. At the conclusion of the visit, I was asked what group I thought best fit my interests, and I replied that the Component Applications group at Murray Hill was my favorite. It was actually a shot in the dark, but it was a lucky one. Tudor Finch, who led that group, was well connected far beyond Bell Labs, and being associated with that group for two years connected me as well. Tudor could be difficult at times, but I got along with him very well after one afternoon in his office when he challenged me to justify what I was doing on our waffle-iron memory. Uncharacteristically, I stood up for what I was doing and pushed back. I still remember the smile on his face as I left his office.

Tudor opened many doors for me, and it was he who suggested that I do my master's degree at Stanford, where many of his friends from the early transistor days had migrated. I had the privilege of getting to know many of them. Jim Angell, my thesis chairman, was also the university carillonneur, and one afternoon as we were checking the tuning of the bells in Hoover Tower, we were joined by Robert Noyce and his son. Several years later when Bob visited Michigan, he reminded me how far out of tune one of the bells there had been. It was said of Noyce that "he made every man his peer," and in my experience that was true. I was fortunate to know some real pioneers, many of whom served in various ways as role models.

I recently enjoyed reading Walter Isaacson's *Benjamin Franklin: An American Life*. Franklin is a person I trace my professional lineage to. That may seem odd, since we usually think of him as a diplomat. Indeed, he was the only person to sign all four documents that established our nation—the Declaration of Independence, the treaty with France, the peace accord with Britain, and the Constitution. However, Franklin thought of himself primarily as a printer. He was not a great orator, and usually preferred to sit in the background (I can relate to that); he *was* a prolific writer. But perhaps more than anything else, Franklin was an engineer. He was driven by a desire to understand how things worked and then apply them to solving problems. There were bifocals, the Franklin stove, the first urinary catheter, and other inventions, but his most lasting contributions came in electricity. His work helped create the foundation for electrical engineering. When he started, that "great force of the universe was understood a little better than it had been by the ancients." It is to him we owe the terms battery, charged, condense, neutral, and conductor. He defined current as the flow of positive charge (and it still seems that nature was a bit perverse in not arranging things that way). He defined the law of conservation of charge, called by Harvard Professor Bernard Cohen "of the same fundamental importance to physical science as Newton's law of conservation of momentum." Until Franklin invented the lightning rod, being a church bell ringer was dangerous business since "during one 35-year period in Germany alone during the mid-1700s, 386 churches were struck and over one hundred bell ringers killed." Indeed, the tremendous respect and celebrity that greeted Franklin in France during his service there at the time of the Revolution was largely due to his fame in taming electricity. Come to think of it, I suppose a serious argument could be made that our nation was established by an electrical engineer. Maybe that's why it (and some companies) work as well as they do. We all need good role models. Franklin is another one of mine.



Ken D. Wise

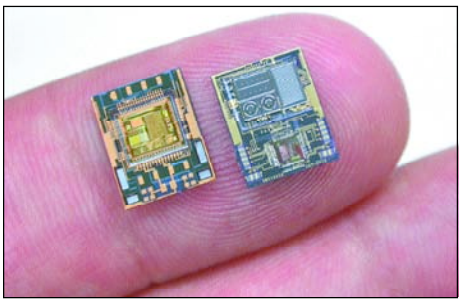
Director, Engineering Research Center for
Wireless Integrated MicroSystems

Inside

Research Highlights

An Integrated Microsystem for Autonomous Data Gathering (2005)

David Lemmerhirt and Kensall D. Wise



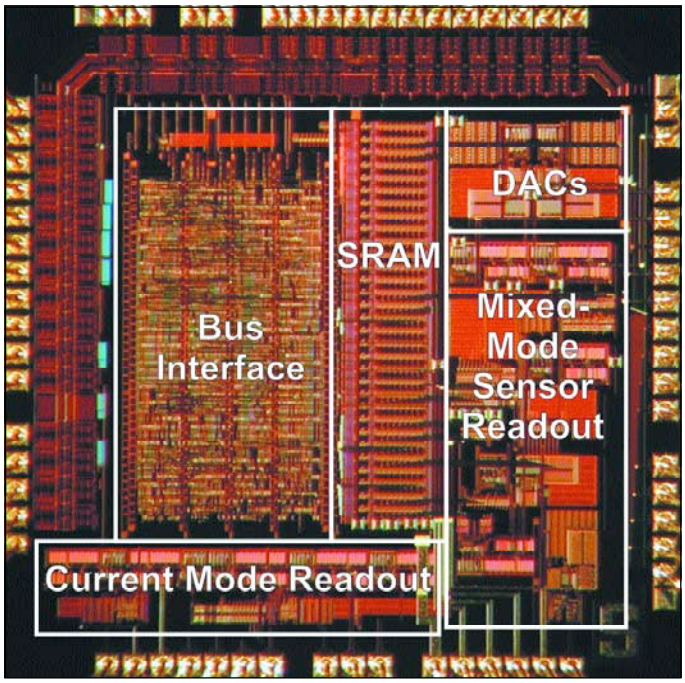
Front and back views of integrated microsystems for autonomous data gathering.

A microsystem for sensing and storing biological and environmental data has been realized in a volume of only 0.15cc. The microsystem consists of a custom sensor-interface chip, a mixed-signal microcontroller, and a 16Mb non-volatile memory together with on-board capacitive pressure/temperature/humidity sensors, off-board strain gauges, and neural/EMG recording electrodes. It is integrated on a micromachined silicon platform that implements through-wafer interconnects, solder-based microconnectors, and recessed cavities for chip-stacking. The microsystem operates at less than 50μW from a 3V lithium battery when reading capacitive sensors at 1Hz using a switched-capacitor charge integrator. This integrator uses a 10-bit programmable reference capacitor, and provides a gain that is adjustable from 0.4mV/fF to 3.2mV/fF. The data-acquisition rate, data-conversion resolution, and power management are all software controlled. The system defaults to 14-bit acquisition for environmental sensing and to 8-bit acquisition for biological sensing. The sampling rate can range from 10^{-4}kHz to 10kHz, with the upper limit imposed by the serial communication speed between the microcontroller and the flash memory. The platform allows microsystem realization in 9.5mm x 7.6mm x 2.0mm (0.15cc) (<0.5cc with battery). This microsystem is representative of the devices that are the focus for the WIMS ERC.

A Highly Adaptive Sensor Interface Circuit for Multiple Signal Modes

Jichun Zhang, Junwei Zhou, and Andrew J. Mason

Microsystems often employ multiple sensors to complete sophisticated measurement and monitoring tasks, relying on transducers with a wide variety of output signal modes, ranges, and sensitivities. To enable such multi-sensor microsystems to be readily produced, a highly adaptive sensor interface circuit was developed that supports capacitive, resistive, voltage, and current-mode transducers. Called the Universal MicroSystem Interface (UMSI), this chip incorporates a sensor bus interface (compatible with the IEEE P1451 standard) and a programmable low-noise analog readout circuit to form a single chip link between a microsystem controller and a wide range of transducers. The adaptive analog front end supports capacitive sensors with up to 30mV/fF sensitivity, resistive sensors with up to 18mV/Ω (at 22kΩ) sensitivity, voltage gain or attenuation, and current readout with sub-pA resolution. The UMSI chip also includes programmable digital and analog output signals for actuator control and additional circuitry for self-test and calibration. The circuit supports plug-and-play operation and a variety of power management modes, and it includes an interface-to-application-specific external components. Fabricated in 0.5μm CMOS with a 3V supply, the 2.2 x 2.2mm chip dissipates around 3.3mW during sensor readout and only 13μW during its low power mode.



Die photograph of the 2.2mm x 2.2mm mixed-signal Universal MicroSystem Interface circuit.

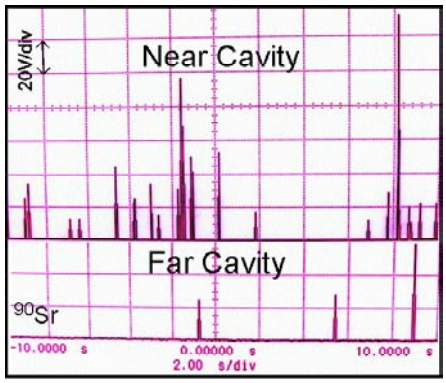


Figure 1: An oscilloscope trace of the upper (near) cavity of the D-microGeiger shows more pulses per unit time than the lower (far) cavity, for which the intermediate glass layer blocks the lower energy particles.

Micromachined Beta Particle Detector Providing Energy Spectroscopy

Christine Eun and Yogesh B. Gianchandani

A micromachined radiation detector capable of energy spectroscopy has been developed. The D-microGeiger is a double-stacked device with aligned cavities and is fabricated from stacks of glass and Si wafers. The glass substrate between the two cavities, which can have varying thickness, provides calibrated energy absorption. As a beta particle passes through, a bias applied between two enclosed electrodes generates electron cascades in the gas between them. This results in a current pulse or "count". Lower energy beta particles are only detected in the upper cavity, while higher energy particles are detected in both cavities (Figure 1). A single die of $2cm^2$ holds 6 independent chambers ranging in size from 8 x $8mm^2$ to 1 x $3mm^2$. Helium and neon, which have different voltage bias requirements, were separately evaluated as background gases. In tests the device was found to detect incident beta particles from calibrated ^{90}Sr, ^{60}Co, and ^{204}Tl sources of 0.1-1 μCurie strength.

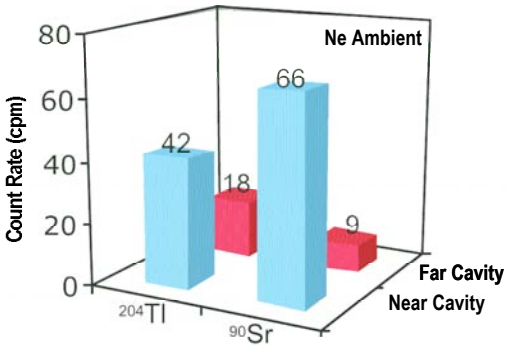
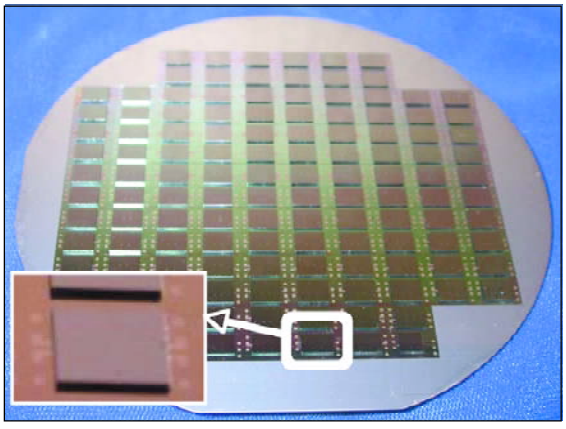
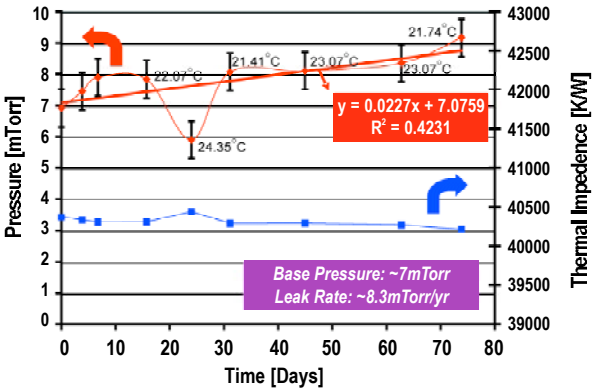


Figure 2: Count rates for the D-microGeiger detecting two different isotopes, including counting rates for the upper and lower cavities. The upper cavity consistently detected more particles than the lower cavity, confirming the assumption that the higher energy beta particles are detected by both cavities while the lower energy particles are detected by the upper cavity alone.





Wafer-Level Vacuum Package With Leak Rate of <10mTorr/Year

Jay Mitchell, G. Roientan Lahiji, and Khalil Najafi

A wafer-level vacuum package based on silicon-gold eutectic bonding has been developed. A silicon wafer containing MEMS devices is capped at the wafer level by a second silicon wafer that is bonded to it using silicon-gold eutectic bonding. The process has been optimized to provide better than 90% yield and is uniform and reproducible (photo). Micromachined Pirani gauge vacuum sensors have been fabricated to measure the leak rate inside the package. Without using getters inside the package, the leak/outgassing rate is quite high and the minimum achievable pressure is about 1 Torr. However, when Nanogetters™ provided by Integrated Sensing Systems, Inc. (ISSYS) are used, base pressures as low as 7mTorr have been achieved. Measured leak/outgassing rate based on a three-month test has been measured to be about 8mTorr/year (see figure). These tests are continuing, and more detailed test data will be available in the future.

Recent Events

Stephen Director presents Ken Wise with award.

Professor Wise Receives Pioneer Award

Kensall Wise, Director of the WIMS ERC, received the Small Tech Industry Pioneer Award during the *Fifth Annual Emerging Industry Symposium: The Business Reality of Micro and Nano Technologies*. Stephen W. Director, the Robert J. Vlasic Dean of Engineering at the University of Michigan, presented the award.

The symposium (March 31–April 1, 2005), sponsored by the University of Michigan's Office of Technology Transfer, the Samuel & Robert H. Lurie Institute for Entrepreneurial Studies, and the Michigan Small Tech Association, also featured Wise's presentation, "Microsystems and MEMS—An Overview".

Wise began teaching in 1974 at the University of Michigan in the College of Engineering. He is presently the J. Reid and Polly Anderson Professor of Manufacturing Technology, William Gould Dow Distinguished University Professor of Electrical and Computer Science, and a professor in Biomedical Engineering.

Faculty/Student Awards

Professor Kamal Sarabandi has been chosen to receive the 2005 IEEE Geoscience and Remote Sensing Society (GRSS) Distinguished Achievement Award. This award recognizes an individual "who has made significant technical contributions, usually over a sustained period."

Professor Sarabandi is also receiving a 2004–05 University of Michigan Faculty Recognition Award from the Rackham School of Graduate Studies. Recipients are recognized for their "substantive contributions to the University through significant achievements in research and other scholarly/creative activities; excellence as a teacher, advisor and mentor; and distinguished participation in the service activities of the University.

Nader Behdad, one of Sarabandi's PhD students, was awarded the University of Michigan's Rackham Predoctoral Fellowship. This prestigious fellowship is awarded to outstanding PhD students who will complete their dissertation within a year of receiving the fellowship.

Personnel Focus

Sastry Elected ASME Fellow

Professor Ann Marie Sastry has been elected to the grade of ASME Fellow.

Professor Sastry's research has made significant contributions to energy technologies, biological modeling, and understanding of the fundamental percolation properties of complex heterogenous systems. She is an associate editor of the *ASME Journal of Materials and Technology* and the *Materials Physics and Mechanics*. She has served as the chair of the ASME Applied Mechanics Division Technical Committee on Manufacturing and Materials Processing, and is currently the chair of the ASME Materials Division Technical Committee on Composite Materials. She also serves as the vice chair and chair elect of the ASME Applied Mechanics Division Technical Committee on Composite materials.

Professor Sastry has received numerous professional honors including a 1997 NSF PECASE, the 1999–2000 College of Engineering 1938E Award, and the University of Michigan's 1999 Henry Russell Award for distinguished achievements in research. Recently, she was awarded the University of Delaware's Presidential Citation for Outstanding Achievement, which honors graduates of the past 20 years who exhibit great promise in their professional and/or public service activities.

Dennis Sylvester Named New Micropower Thrust Leader

Two changes in WIMS ERC administration have taken place recently. Professor Michael Flynn, who has been serving as Interim Leader for the Wireless Interfaces Thrust, has agreed to drop the "interim" and serve as the Thrust Leader. Over the past two years, Professor Flynn has done a fine job managing the wireless activities of the ERC. The thrust is well organized with clearly defined goals and objectives. It is one of the real strengths of the Center.

Secondly, with the departure of Richard Brown, now Dean of Engineering at the University of Utah, it became necessary to identify another Thrust Leader for the Micropower Circuits area. Dennis Sylvester, an electrical engineering associate professor at University of Michigan, has agreed to serve in this capacity. Sylvester's work in micropower digital circuits fits very well into the goals of the Center. We look forward to working with him as he begins guiding our micropower efforts

Education Highlights

WIMS Students Receive CoE and EECS Department Honors

WIMS graduate and undergraduate students received awards and prestigious nominations for academic, research, and service achievements recently in College of Engineering (CoE) and Department of Electrical Engineering and Computer Science (EECS) Awards during March. All selections for awards and CoE nominations were by the EECS Undergraduate Committee and the EECS Graduate Committee.

David Lemmerhirt received the Distinguished Achievement Award for an EECS Graduate Student at a CoE brunch, Sunday, March 20, 2005. David was nominated based on his exceptional mentoring of two undergraduate students, David Fick and Patrick Macnamara, in research projects, titled "Data Acquisition Software for An Ultraminiature Microsystem" during 2004. The system collapses a 16 MB memory, microprocessor, and sensors for pressure, humidity, and temperature into a finger-tip size microsystem (see article in Research Highlights). Also, David mentored undergraduate research students in Summer 2002 and 2003. Through his quality mentoring, Lemmerhirt contributed to a more enriching educational experience for these undergraduate students. Lemmerhirt recently completed his PhD degree with faculty advisor Professor Ken Wise.

Patrick Macnamara, Lawrence McAfee, and Jack Li

Helena Chan was nominated for the Marian Sarah Parker Award (graduate student category), in recognition of her leadership, community service, and academic excellence. Helena has been very active in the WIMS Student Leadership Council (SLC), having served as chair of two committees. She has been a mentor for the DAPCEP Spring Program for four years. She has been a leader for the twice-yearly blood donation drive for North Campus. Helena is a PhD student advised by Professor Stella Pang.

Patrick Macnamara was the Computer Engineering nominee for the esteemed Henry Ford II Distinguished Class Prize, a CoE award for the outstanding junior level student who has demonstrated academic excellence. WIMS research experience is believed to be an important factor in his selection as nominee. During summer 2004, Patrick worked with David Lemmerhirt on the project "Data Acquisition Software for an Ultraminiature Microsystem." As noted above, David Lemmerhirt is a PhD student advised by Professor Ken Wise. Presently, Patrick is modeling MEMS in a research project with Professor Gianchandani's group.

Lawrence McAfee was the Electrical Engineering nominee for the esteemed Henry Ford II Distinguished Class Prize, a CoE award for the outstanding junior level student who has demonstrated academic excellence. WIMS research experience is believed to be an important factor in his selection as nominee. During Summer 2004, Lawrence worked with Jianbai Wang on the project "A Tip Sensor and Its Noise Analysis in a Contact Sensing System for Cochlear Prosthesis." Jianbai Wang is a PhD student advised by Professor Wise.

Albert Chen, Gregory Chen, Jack Li, Danny Lin, Patrick Macnamara and **Lawrence McAfee** were designated Senior Scholars in EECS, a designation for junior level students with GPA at least 3.90. Each is a current or former WIMS undergraduate research student. Also, Jack Li was nominated for the CoE A.D. Moore Award, an award for a sophomore or junior who has demonstrated academic excellence, leadership qualities, and outstanding contributions to co-curricular activities.

Chenlu Hou received numerous CoE and EECS honors. Chenlu was nominated for and received the CoE Distinguished Achievement Award, an award for an undergraduate student at any level. Chenlu was nominated for two other CoE awards: the Marian Sarah Parker Undergraduate Prize, an award for the outstanding woman senior student; and the Society of Women Engineers (SWE) Outstanding Female at UM. In previous years, Chenlu was designated a Junior Scholar and then a Senior Scholar in EECS. During Summer 2003, Chenlu worked on a research project with Alan Drake, who has completed his PhD research advised by Professor Brown (now Dean of Engineering at the University of Utah). Chenlu is presently deciding about which graduate school to attend.

Intel International Science Fair Winner

Farre Nixon is a junior in high school from Texarkana, Texas. She was accepted to NASA SHARP (Summer High School Apprentice Research Program) for the summer of 2004, and she was matched to Daryl Kipke's Neural Engineering Lab (NEL). Under the mentorship of graduate student Tim Marzullo, she worked on learning computer programming skills for analysis of neural data in brain-machine interfaces. She entered, and won, the Intel International Science Fair at the regional level, and is going to state and internationals for her work at the UM NEL. She plans to study biomedical engineering in college.

Education Highlights (continued)

Science, Engineering, and Technology Day at MSU

Michigan State University WIMS ERC students introduced prospective MSU students to WIMS at MSU's Science, Engineering, and Technology Day (SET Day) February 26, 2005. SET Day opens MSU campus to high school students and their families, allowing them to see engineering facilities; watch demonstrations; and talk to faculty, current students, and staff about opportunities afforded by science and technology careers. WIMS students set up a booth where they focused on explaining three key aspects of WIMS: teaching, research, and K–PhD education. They informed visitors about the WIMS courses offered at MSU, gave demonstrations with LEGOs to illustrate how research can take a very elementary concept and develop it into cutting-edge technology, and they presented how WIMS is linking K–PhD education with graduate research. An equivalent event was at UM's Tech Day on November 6, 2004.

High school students and their parents watch demonstrations on SET Day at MSU.

Saturday Morning Detroit Area Pre-College Engineering Program at WIMS

WIMS mentor helps student.

A big congratulations goes out to all the mentors who participated in this year's 2005 Detroit Area Pre-College Engineering Program (DAPCEP). Over five weekends in March and April, several teams of middle school students from the Detroit area learned the fundamentals about WIMS and applied their knowledge with LEGO™ robots and digital electronics. The groups were given several tasks to complete with their robots and received certificates based on the skills they demonstrated. The WIMS Center and EECS students served as mentors to the sixteen outstanding seventh and eighth graders, exposing them to basic electrical engineering and science concepts and challenging their mathematical skills. The student mentors were there to answer questions and help with the more difficult challenges. The five week program covered a dynamic range of subjects: what are WIMS devices, the use of WIMS devices, and the societal impact of this technology. Students were challenged, using LEGO™ Mindstorms, to mimic a WIMS device by developing and programming robots to perform a designed actuation using touch, light, and rotational sensors. Students were also exposed to the operation of Logic Gates and the uses of LEDs in circuits. The DAPCEP program is designed to expose urban youth to engineering and show that science can be fun.

Students demonstrate how their robots work.

Industrial Liaison's Report

We have just completed the *Fifth Annual Emerging Industry Symposium: The Business Reality of Micro and Nano Technologies*. The symposium, attended by over 200 people, took place in Ann Arbor and was presented by the University of Michigan and Michigan Small Tech Association (MISTA). The highlight of the symposium was the presentation of the Small Tech Industry Pioneer Award to Professor Wise (p. 4). Professor Wise also gave an overview of Microsystems and MEMS to an audience that consisted mainly of business people and educators. The session was designed to help this audience understand how MEMS has impacted and will continue to impact the average person's life. As part of his presentation, Professor Wise discussed the ten MEMS-based spin-off companies using technology developed at the university. A tour of our laboratory facilities was provided for some of the attendees. WIMS students guided tours of the cleanroom, which supports both the WIMS ERC and the National Nanotechnology Infrastructure Network, and demonstrated some of our devices. One purpose of the tour was to illustrate the reality and function of these devices. The demonstrations included the micro gas chromatograph, auditory implant devices, brain micro implant devices, and the remote-powered stentenna. All these projects, as well as other WIMS projects, will be updated and discussed at our next Industrial Advisory Board meeting on May 25, 2005.

A number of our member companies took part in the symposium panel discussions that addressed such topics as business models and funding for MEMS ventures. These sessions were designed to assist both technical and business people in developing commercially viable MEMS-based companies.

The Centers' participation in the symposium is part of our continuing effort to make the business community aware of our technology. The participation by our member companies emphasizes the entire WIMS community commitment to successfully commercializing technology.

As always, please visit when in the Ann Arbor area.

Joseph M. Giachino
Associate Director, Industry

Presentations and Publications

Conference Presentations

IEEE International Conference on Micro Electro Mechanical Systems (MEMS), Miami Beach, FL, January 2005

A. Basu and Y. B. Gianchandani, "High Speed Microfluidic Doublet Flow in Open Pools Driven by Non-Contact Micromachined Thermal Sources"

A. B. Ucok, J. Giachino, and K. Najafi, "Modular Assembly/Packaging of Multi-Substrate Microsystems (WIMS Cube) Using Thermo-Magnetically Actuated Cables"

B. H. Stark, J. Chae, A. Kuo, A. D. Oliver, and K. Najafi, "A High-Performance Surface-Micromachined Pirani Gauge in SUMMIT V™"

B. Mitra and Y. B. Gianchandani, "The Micromachined FlashFET: A Low-Power, Three-Terminal Device for High Speed Detection of Vapors at Atmospheric Pressure"

J. A. Potkay and K. D. Wise, "An Electrostatically Latching Thermopneumatic Microvalve with Closed-Loop Position Sensing"

J. Chae, J. Giachino, and K. Najafi, "Wafer-Level Vacuum Package with Vertical Feedthroughs"

J. S. Mitchell, G. R. Lahiji, and K. Najafi, "An Improved Performance Poly Si Pirani Vacuum Gauge Using Heat Distributing Structural Supports"

J. Wang, M. N. Gulari, P. T. Bhatti, B. Y. Arcand, C. R. Friedrich, and K. D. Wise, "A Cochlear Electrode Array with Built-In Position Sensing"

K. Takahata and Y. B. Gianchandani, "Micromachined Intraluminal Devices for Active and Passive Electromagnetic Measurements of Flow"

K. Udeshi, K. Liao, L. Que, A. Galvanauskas, and Y. B. Gianchandani, "A Micromachined Platform for Localized Index Modulation in Chirped Fiber Bragg Gratings and Its Application to Ultrafast Optical Pulse Shaping"

M. Agah and K. D. Wise, "A Fully-Dry PECVD-Oxynitride Process for MicroGC Column Fabrication"

M. U. Demirci and C. T.-C. Nguyen, "Single-Resonator Fourth-Order Micromechanical Disk Filters"

S. A. Nikles, S. C. Bledsoe, R. M. Bradley, and K. Najafi, "A 32-Channel Active High-Density Connector for Biomedical Applications"

S. Lee, J. Chae, S. Yoon, N. Yazdi, and K. Najafi, "Low-Power Thermal Isolation for Environmentally Resistant Microinstruments"

T. Li and Y. B. Gianchandani, "A Die-Scale Micromachining Process for Bulk PZT and Its Application to In-Plane Actuators"

W. C. Welch and K. Najafi, "Transfer of Metal MEMS Packages Using a Wafer-Level Solder Sacrificial Layer"

Y. Xie, S.-S. Li, Y.-W. Lin, Z. Ren, and C. T.-C. Nguyen, "Spurious Mode Suppression in UHF Micromechanical Extensional Wine-Glass Mode Ring Resonators"

International Symposium on Quality Electronic Design (ISQED), San Jose, CA, March 2005

H. S. Deogun, R. M. Rao, D. Sylvester, R. B. Brown, and K. J. Nowka, "Dynamically Pulsed MTCMOS with Bus Encoding for Total Power and Crosstalk Minimization"

J. Sivagnaname, H. C. Ngo, K. J. Nowka, R. K. Montoye, and R. B. Brown, "Controlled Load Limited Switch Dynamic Logic Circuit"

R. M. Rao, K. Agarwal, A. Devgan, D. Sylvester, R. B. Brown, and K. J. Nowka, "Parametric Yield Analysis and Constrained-Based Supply Voltage Optimization"

IEEE International Solid-State Circuits Conference (ISSCC), San Francisco, CA, February 2005

P. Mohseni and K. Najafi, "A Battery-Powered 8-Channel Wireless FM IC for Biopotential Recording Applications"

R. H. Olsson III and K. D. Wise, "A Three-Dimensional Neural Recording Microsystem with Implantable Data Compression Circuitry"

J. Sivagnaname, H. C. Ngo, K. J. Nowka, R. K. Montoye, and R. B. Brown, "Study of Wide LSDL Circuit Implementations," Austin Center for Advanced Studies Conference, Austin, TX, February 2005.

K. Agarwal, D. Sylvester, D. Blaauw, and A. Devgan, "Achieving Continuous Vth Performance in a Dual-Vth Process," ACM/IEEE Asia-South Pacific Design Automation Conference, Shanghai, China, January 2005.

M. Ghovanloo and K. Najafi, "A Tri-State FSK Demodulator for Asynchronous Timing of High-Rate Stimulation Pulses in Wireless Implantable Microstimulators," to appear at the 2nd Intl. IEEE/EMBS Conf. on Neural Engineering, March 2005.

R. A. Ravindran, P. D. Nagarkar, G. S. Dasika, E. D. Marsman, R. M. Senger, S. A. Mahlke, and R. B. Brown, "Compiler Managed Dynamic Instruction Placement in a Low-Power Code Cache," International Symposium on Code Generation and Optimization (CGO), San Jose, CA, March 2005.

R. Bai, N. S. Kim, D. Sylvester, and T. Mudge, "Power-Performance Tradeoffs in Nanometer-Scale Multi-Level Caches Considering Total Leakage," ACM/IEEE Design, Automation, and Test Europe (DATE), Munich, Germany, March 2005.

Y. S. Lin and D. Sylvester, "A New Asymmetric Skewed Buffer," ACM/IEEE International Conference on VLSI Design, Kolkata, India, January 2005.

Publications

A. DeHennis and K. D. Wise, "A Wireless Microsystem for the Remote Sensing of Pressure, Temperature, and Relative Humidity," *IEEE/ASME Journal of Microelectromechanical Systems (JMEMS)*, pp. 12–22, February 2005.

J. Chae, H. Kulah, and K. Najafi, "A CMOS-Compatible High-Aspect-Ratio Silicon-On-Glass In-Plane Micro-Accelerometer," *Journal of Micromechanics and Microengineering*, vol. 15, no. 2, pp. 336–345, February 2005.

M. Ghovanloo and K. Najafi, "A Compact Large Voltage-Compliance High Output Impedance Programmable Current Source for Implantable Microstimulators," *IEEE Transactions on Biomedical Engineering*, vol. 52, no. 1, pp. 97–105, January 2005.

N. Behdad and K. Sarabandi, "A Wide-Band Slot Antenna Design Employing a Fictitious Short Circuit Concept," *IEEE Transactions on Antennas and Propagation*, vol. 53, pp. 475–482, January 2005.

Doctoral Dissertations

Ken'ichi Takahata, "Batch Manufacturing Technology Based on Micro-Electro-Discharge Machining and Application to Cardiovascular Stents"
University of Michigan, 2005
Advisor: Yogesh Gianchandani

Fatih Kocer, "A New Transponder Architecture for Long Range Telemetry Applications"
University of Michigan, 2005
Current Position: Hittite Microwave Turkey, Maslak Istanbul, Turkey, starting this summer
Advisor: Michael P. Flynn

Enrique Jose Duarte-Melo, "Field-Gathering Wireless Sensor Networks: Throughput Scaling Laws and Network Lifetime"
University of Michigan, 2005
Current Position: Boston Consulting Group (BCG), starting in September
Advisor: Mingyan Liu

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Sandia National Labs

*** January 18, 2005**
Professor Nicholas Kotov
University of Michigan

*** January 25, 2005**
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Jay Mitchell
Jaehyun Park
UM Graduate Students

*** February 15, 2005**
Professor Jingming Xu
Brown University

*** February 22, 2005**
Michael Rowe
UM Graduate Student
Nelson Sepulveda-Alancastro
MSU Graduate Student

*** March 8, 2005**
Dr. Kurt Petersen
SiTime Corporation

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